REVIEW ARTICLE

Rural development towards a bio-based economy – the contribution of Forest Research

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Abstract

The bio-economy, using biomass from various sources and in a wide range of sectors, has reached a significant scale in Europe. The current and the potential importance of the bio-economy is illustrated with data from Germany. While the potential uses of biomass are manifold, its availability is limited. This paper discusses the resulting competition for biomass and shows possibilities to increase the biomass-potential. To satisfy the increasing demand for biomass, further research in the forestry sector is needed.

Key words

bio-economy, biomass, potentials, utilization cascades, cycle concepts

Introduction

The Bio-Economy includes all industries and economic sectors that produce, manage or otherwise make use of biological resources including bio-waste (definition after Patermann 2007).

Today, the European bio-economy has an approximate market size of over € 1.5 trillion, employing more than 22 million people and includes the food sector, the fibre sector, the fuel sector and the feed sector (the four "F's"). This means that the bio-economy touches nearly all fields of our everyday life. Therefore, the main questions concerning the bio-based economy in the future are:

– What are the possibilities, advantages and effects that a bio-economy offers?
– What are the feasible resources to supply a bio-economy?
– What are the potentials of these resources?

Due to the complexity of this subject, answers to these questions are difficult, but not impossible.

According to Patermann (2007), the Bio-Economy offers improvements concerning environmental issues, health situation, rural development and industrial competitiveness.

Environment: The bio-economy offers the possibility of a sustainable and ecologically compatible economic system. This can be achieved on the one hand, by implementing resource-saving guidelines, like energy and water saving aspects in production and other processes or the substitution of fossil resources with renewable resources, and on the other hand by disclaiming

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phosphorus in products and by reducing the CO_2 emissions.

Health: The bio-economy also helps to improve the world's health situation by offering food with improved nutritional value, by increased food safety, by new treatments, diagnosis and vaccines against animal diseases and by improved feed.

Rural development: The bio-economy offers the chance to promote rural development. The increasing demand for renewable resources strengthens the rural areas as producers of these resources. By reactivating "set-aside" land, by cultivating new crops and by installing production facilities in rural areas, this decentralised approach offers new opportunities for rural areas to develop.

Industry: The adaptation of the industry towards changing ecological, climatic and social requirements through the implementation of a bio-economy leads to an increased competitiveness of eco-efficient bio-based products.

Regarding the feasible sources of biomass, there are three main options, namely agriculture, forestry and landscape management. All of them can provide raw biomass, but in different forms and with different end-products.

Agriculture can deliver field crops or crop residues, forestry can deliver woody biomass (wood, bark, needles or leaves), and landscape management can deliver both woody biomass (wood, bark leaves/needles), as well as loppings or grassy biomass.

As shown in diagram 1, raw biomass coming from one of these sources can either be used as an energy source or in non-energetic ways.

If raw biomass was used in non-energetic ways, the respective process residues or waste material can be conditioned after use (e.g. solid biomass to biogas/wood or straw pellets, BtL….) and then used in an energetic way. This leads us to the material flow model as shown in figure 1.

In the further comments, the focus is set on woody biomass from forests.

The opportunities of using wood in a bio-based economy are manifold. Four main economic sectors in which wood is mainly used can be identified: the construction & living sector, the pulp and paper industry, the biorefinery industry and the bio-energy sector.

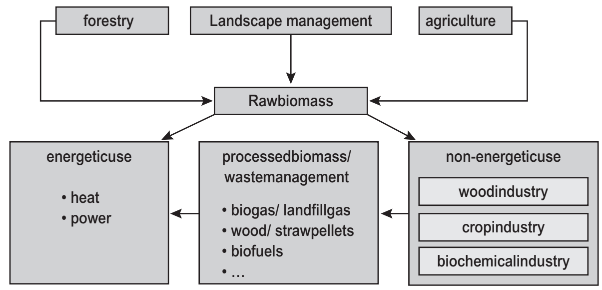

Fig. 1. Material flow model of a bio-based economy

Regarding the construction and living sector, high quality wood in the form of logs as well as wood with a lower quality (e.g. industrial wood for the panel industry) can be used as material for structural and civil engineering purposes, for furniture and for interior design. It therefore represents a high value raw material.

Wood with a lower quality is also used in the pulp and paper industry, in the biorefinery industry with its main products Btl (synthetic fuels), plastic chemicals, DME[1] and methanol and finally in the bio-energy sector, where wood is processed to split logs, wood chips or wood pellets. Due to this broad range of possible forms of utilisation for wood with a lower quality and due to its limited availability, the different economic sectors compete for wood with a lower quality.

Status quo from a German perspective

Currently, about 61.7 million m³ of wood are harvested in Germany every year. These cuttings are distributed on the economic sectors (shown in figure 2) the following way:

The main proportion, about 67 % of the wood harvested in Germany's forests (ca. 35 million m³ of logs, ca. 6.3 million m³ of industrial wood (for panel industry) is used in the economic sector "construction & living".

About 10 % (ca. 6.2 million m³ industrial wood) is used in the pulp & paper industry, whereas this amount only represents about 13.8 % of the total raw product input in this economic sector (VDP 2006).

Unfortunately, no database about the usage of forest wood in the biorefinery sector is available, but in 2004 renewable resources approached 10 % of the total raw

1 DME= dimethyl esther

product input in this economic sector (VCI 2001, 2004). The following integrated biorefinery approach by Girard *et al.* (2006) (fig. 3) shows the possibilities biomass offers in that economic sector:

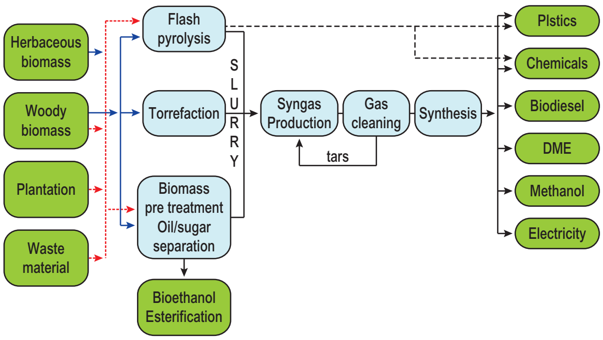

Fig. 2. The integrated biorefinery approach (Girard *et al.* 2006)

Referring to current studies, about 23 % of the annual German cuttings (logs: ca. 8.8 million m³, industrial wood: 3.7 million m³, residual wood from forests: 1.7 million m³) are used in the bio-energy sector (Mantau and Bilitewski 2005, Ochs *et al.* 2007). Due to a lack of statistical data, it is quite difficult to determine the utilisation of forest wood for energetic purposes, especially from small scale private forests. This means that these data have been estimated. The "real" energetic usage might be higher.

Potentials in Germany

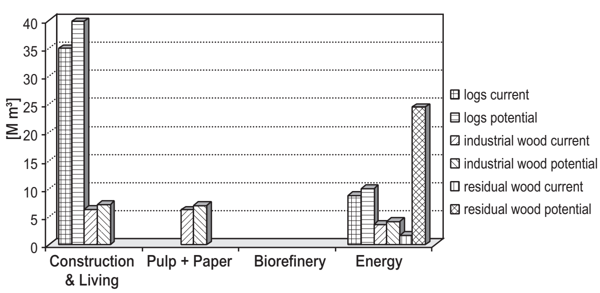

Fig. 3. Comparison of current and potential usage of different assortments from forest wood in certain economic sectors

Recent studies concerning the wood potentials from Germany's forests (Federal Ministry for Food, Agriculture and Consumer Protection of Germany 2002, Mantau and Bilitewski 2005, Hepperle 2007, Ochs *et al.* 2007, von Teuffel and Hepperle 2007) identify only a few possibilities to enhance the usage of logs and industrial wood.

Regarding logs and industrial wood, the current total annual utilisation is ca. 44 million m³ of logs and 16.2 million m³ of industrial wood. By means of an intensification of the annual harvesting activities in Germany the amount of logs could be increased to ca. 50 million m³/a (+ 6 million m³), and the amount of industrial wood up to 18.4 million m³/a (+ 2.2 million m³).

Regarding the utilisation of residual wood, the situation greatly differs. Only a small part of the residual wood resulting from regular harvesting activities in Germany, seems to become mobilised. Therefore, there are two possibilities of increasing the utilisation of residual wood from forests: firstly, this could be managed by an increase of the mobilisation rate and, on secondly, by an intensification of the harvesting activities. The utilisation of residual wood from forests could be enhanced from the current 1.7 million m³/a to 24 –26 million m³/a. This potential of forest residual wood is, if used as an energy source, equivalent to a heating value of about 200 Petajoule [PJ] per year. But even if this amount of residual wood was mobilised completely, it could only provide 1.5% of the total annual primary energy supply [TPES] of Germany (TPES in 2005: 14 236 PJ).

Conclusions

Thanks to its properties, biomass has the potential to substitute almost the whole range of fossil resources, as numerous basic materials and chemical products for various branches of industry may be produced from biomass (SRU 2007). However, the availability of wood and other biomass is limited, which results in inter- and intra-sectoral competition for biomass. Here, markets have an important function in regulating this competition. In certain cases with overriding public interest, for example CO_2 emissions, limited fossil resources or innovative technologies, subsidies and interventions by authorities may be necessary for certain forms of utilization.

The competition for limited resources may be illustrated with the example of the cultivated area for selected crops in Germany: while the cultivated area

for cereals (for food production) decreased from 6.84 Mio ha in 2005 to 6.53 Mio. ha in 2007, the cultivated area for silage maize (for bio-ethanol) increased from 1.26 Mio. ha to 1.48 Mio. ha, and the cultivated area for winter-rapeseed (for bio-diesel) increased from 1.32 Mio. ha to 1.53 Mio. ha over the same period of time (DESTATIS 2007).

To match the growing demand for biomass, the potentials may be increased through the following options:

– increase the (land-) area for the production of biomass,
– increase yield and productivity of biomass cultivation schemes,
– improve the efficiency in using and transforming raw materials,
– establish "utilization cascades" for renewable resources,
– develop and establish cycle concepts.

For many of the above mentioned options, further research is urgently needed.

Future forest research needs

With growing demand for biomass, the role of forests will become more important. To assure that forests can continue to fulfil their ecological and social functions, besides the growing economical function, the following research fields must be addressed:

1. Quantitative aspects and potentials
2. Effects of climate change
3. Wood production
4. Forest-wood supply-chain
5. Competition for utilization
6. Socio-economic aspects

ad 1. Quantitative aspects and potentials

To be able to quantify the potential contribution of the forestry sector to a bio-based economy, it is not only crucial to have detailed data on the area of forest and agricultural land currently available, but also information on the potential future development is needed: which are land areas suitable for afforestation or for the establishment of short rotation plantations, which areas of forest and agricultural land will be converted into other forms of land use?

To assess the growing stock and production of forests in an efficient way, inventory methods need further development and innovative methods should be promoted.

Updated information on growth and yield of biomass is needed, considering wood and timber, but also more detailed for specific assortments, bark i.e.

ad 2. Effects of climate change

For all future management actions in forestry, it is important to pre-estimate how and to what extent the climate will change, not only on the global level, but also on the regional and local levels, and how this climate change will affect tree species distribution in the long term. The next step must be to develop silvicultural systems which are adapted to the changed climate. Another research topic is the influence of climate change on the growing stock, on growth, and yield. Lastly, the climate change also requires new strategies for risk management in forestry, as storm damages might be more intense and more frequent, forest fires may occur more often in a drier climate, and forest pathogens may spread to areas where they have not yet appeared.

ad 3. Wood production

To enhance biomass production, existing silvicultural systems and rotation periods need to be reviewed with regard to both quantity (growth and yield) and quality (assortments, fibre traits). This also includes the selection of species and provenances, which opens new research fields for breeding and genetics. As the establishment and management of short rotation plantations is a relatively new form of land use, further research is urgently needed. For both silvicultural systems and short rotation plantations, the effects on biodiversity and on nutrition cycles in the soil need to be studied closely.

With the growing scarcity of biomass, the use of residual wood will gain in importance. Here, new uses and technologies need to be developed as well.

ad 4. Forest-wood supply-chain

In the forest-wood supply-chain, new research should focus on new harvesting methods for forests and short rotation plantations. More efforts are also required to establish precision forestry on a broader base. Furthermore, researchers will face the challenge of

optimising logistic systems (e.g. harvesting, transport, identification and tracing) and solving the supply chain coordination problem.

ad 5. Competition for utilization of wood

This includes intersectoral competition (energetic vs. non-energetic use) as well as intrasectoral competition (e.g. wood-pellets/chips vs. BtL). Here, it is crucial to understand the mechanisms that create and regulate these forms of competition. The establishment of "utilization cascades" and recycling concepts could help to mitigate this conflict. Massive wood for construction, for example, can be recycled in particle boards, while the energetic use of the particle board stands at the end of this short exemplary utilization cascade.

Further research fields that need to be addressed are "energy and material flow analysis" and "life cycle analysis" (LCA).

ad 6. Socio-economic aspects

The key issues in socio-economic forestry research include the mobilisation of raw materials and the effects on employment in rural areas. With increasing globalization of the forestry and wood sectors, questions on quality management, standardisation, and labelling become more important. There is also an increasing need for forestry to assess its activities through (Ecological) Impact Assessments and to develop ecobalances for its products.

In this context, the role of the state (e.g. subsidies for certain products or legal frameworks) should be discussed and defined.

If scientists and practitioners succeed to address these research topics, the forestry sector can make a relevant contribution towards a bio-based economy.

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